STATE MINING AND GEOLOGY BOARD

Geohazards Committee

R. Tepel, Chair; Erin Garner, Seena Hoose; J. C. Isham

EXECUTIVE OFFICER'S REPORT

ARNOLD SCHWARZENEGGER
GOVERNOR

For Meeting Date: May 8, 2008

Agenda Item No. 2: Review of Strategy to Stabilize Existing Cutslope and Implement Revegetation Measures to Richmond (Chevron) Quarry (California Mine ID # 91-07-0006), Dutra Materials (Operator), Mr. Harry Stewart (Agent), City of Richmond.

INTRODUCTION: The State Mining and Geology Board (SMGB) is the lead agency for all surface mine operations in the City of Richmond that are subject to the Surface Mining and Reclamation Act (SMARA, Public Resources Code Section 2710 et seq.). The Richmond (Chevron) Quarry is located in the City of Richmond, and encompasses approximately 126 acres and includes a processing and recycling plant, and significant volumes of imported stockpiles of landscape debris and construction debris, and asphalt and soil, which is used for reuse and recycling. In response to the need to evaluate the overall stability of an existing cutslope, geotechnical studies have been performed and recently completed by both Dutra Materials (Operator) and the Chevron Energy and Technology Company (adjacent land owner). These studies have been reviewed by the Department of Conservation's Office of Mine Reclamation (OMR) and SMGB staff, and comments and recommendations are provided for the Geohazards Committee's (Committee) consideration.

BACKGROUND: Following conduct of the 2005 SMARA mine inspection of the Richmond (Chevron) Quarry, several violations and corrective measures were noted. The operator is currently under an Order to Comply to provide: 1) a proposed workplan to mitigate an unstable cutslope; 2) a proposed revegetation plan; 3) a re-evaluation of the financial assurance cost estimate to reflect mitigative and stabilization efforts, and current labor and equipment rates; and 4) an amended reclamation plan. At its meeting held on February 8, 2007, the SMGB deferred a previously issued administrative penalty of $90,000, but did require that the operator adhere to a schedule for completion of required tasks to provide an adequate amended reclamation plan and financial assurance cost estimate. At its June 14, 2007, meeting, the SMGB heard from Dutra's and Chevron's consultants regarding the geotechnical work that has been performed to date, preliminary analysis, and possible mechanisms for slope failure. The SMGB moved to forward further geotechnical discussions of slope failure mechanisms, and proposed mitigation alternatives, to the Geohazards Committee, prior to the SMGB considering action on an amended reclamation plan and financial assurance amount. The current approved financial assurance amount is $674,108, which was provided in July 2006. Following the SMGB's regular business meeting, held on November 6, 2006, a proposed schedule was provided by the operator dated January 4, 2007, and revised in correspondence dated January 31, 2007. Since January 2007, progress reports have been provided on a monthly basis.

RECENT GEOTECHNICAL STUDIES:

The operator's consultant, ENGEO Incorporated (ENGEO), performed initial geotechnical evaluations, as documented in their progress report titled "*Preliminary Geotechnical Progress Report*" dated January 23, 2007, and their report titled "*Evaluation of Reclamation Cutslope Stability*" dated February 28, 2007. These reports documented slope deformation development on the cutslope as early as 1985.

The initial reports were reviewed by OMR and SMGB staff as documented in the Executive Officer's correspondence dated May 15, 2007. It was concluded that since the surface mining operation can no longer be reclaimed in accordance with its approved reclamation plan, an amended reclamation plan would be required for the site that meets current reclamation standards pursuant to CCR Section 3502(e). Mitigation of the quarry cutslope as required under CCR 3704(f) was anticipated to be problematic.

It was recommended that the comments provide in the Executive Officer's May 15, 2007, correspondence should be addressed in a final report, which would address a mitigation strategy for the cutslope. In developing a mitigation strategy, discussion of alternatives for achieving reclamation of the quarry cutslope would need to be addressed. It was recommended that each alternative should consider, but not be limited to, the following:

(1) Slope instability and uncertainties as analyzed in ENGEO's report, in previous studies, and/or in subsequent studies that may be performed by Chevron or Dutra;

(2) The preferred continuation of the existing industrial use on the quarry floor;

(3) Issues relating to protection of Chevron's Tank No. 1799, public health and safety, and the environment; and

(4) Recommendations for consideration by the SMGB on how best to achieve final reclamation of the quarry cutslope.

In correspondence dated March 29, 2007, two options were outlined as discussed during a meeting held on March 27, 2007, between representatives of Dutra, LSA Associates, ENGEO, Chevron, and OMR and SMGB staff: 1) consider mitigating the unstable cutslope, or 2) consider conducting a long-term monitoring program of the unstable cutslope. Prior to finalizing the geotechnical report, the operator was to present to the SMGB its mitigation strategy for the cutslope at its regular business meeting scheduled for June 14, 2007, as re-affirmed in their May 29, 2007, correspondence.

At the SMGB's regular business meeting held on June 14, 2007, the SMGB heard from Dutra's and Chevron's consultants regarding the geotechnical work that had been performed to date, preliminary analysis, and possible mechanisms for slope failure. It was concluded that the slope had experienced complex deformation shortly after cutslope grading was completed, but no movement had been noted since February 2007. It was reported that some shallow movement had been observed, assigning a seismic coefficient would be difficult, and establishment of a setback was being considered. ENGEO reported that a deep-seated mechanism for failure was inferred, which was contrary to the preliminary interpretation of a shallow mechanism as inferred by Chevron's consultants, Geosyntec. ENGEO indicated that three additional borings were planned to resolve the issue of slope failure mechanism, among other issues. Based on the August 30, 2007, monthly progress report, the overall schedule had been modified, and core samples were being reviewed by Engeo on behalf of Dutra, and by GeoSyntec/MMI on behalf of Chevron.

A status report was presented by both consultants at the Geohazards Committee's September 12, 2007, meeting. Since the September 12, 2007, Committee meeting ENGEO, on behalf of Dutra, provided their report titled "*Final Report Evaluation of Reclamation Cutslope Stability, Richmond Quarry, Richmond, California*" in two volumes dated October 18, 2007. MMI Engineering Inc. (MMI), on behalf of Chevron, also provided their report titled "*Geoengineering Evaluation of the Static and Seismic Slope Stability of Tank T-1799*" dated September 7, 2007. The Committee heard a synopsis of these reports at their meeting held on September 12, 2007.

REVIEW OF GEOTECHNICAL STUDIES: The geotechnical studies performed by MMI and ENGEO were reviewed by Mr. John Wesling (Senior Engineering Geologist with OMR), Mr. Will Arcand (Senior Engineering Geologist with the SMGB), and the Executive Officer. ENGEO's October 18, 2007 report titled "*Final Report Evaluation of Reclamation Cutslope Stability, Richmond Quarry, Richmond, California*" made the following key findings with relation to the stability of existing quarry cutslopes at the subject site:

- Significant deformation of the southwest-facing main quarry cutslope appears to have developed between 1985 and 1988. Between 1999 and 2007 the slope does not appear to have experienced visibly discernable movement.

- Lack of an obvious triggering mechanism, such as a large earthquake or intense winter resulting in a markedly increased rate of deformation, indicates that the triggering mechanism has been removal of lateral support and subsequent rebound/dilation of the underlying rock mass following cutslope construction.

- A complex band of deformation traverses the cutslope and is defined by an "*upper bounding scarp*" and "*lower bounding scarp*". The upper bounding scarp is 2 to 6 feet high, displaces the ridge top to the east of the cutslope rim, and extends to within approximately 20 feet of Chevron Tank 1799 before losing definition. The lower bounding scarp consists primarily of an approximately 4-foot high, uphill-facing scarp. Maximum displacements on the cutslope and adjacent ridge are noted to be in the range of 4 to 6 feet.

- Mechanisms of slope movement are inferred to be a complex interaction of slumping both along and across bedding planes, toppling facilitated by bedding parallel slip, and slumping and under-thrusting of blocks along pre-existing tectonic shear zones.

- Depth of movement is uncertain and is estimated on the order of 60 feet below the top of the slope and 20 feet or less below the middle slope, and "*is likely accommodated over depths several 10's of feet as small incremental movements rather tha[n] as a discrete shear surface*."

- Although limited due to variable model input parameters, a conservative limit equilibrium slope stability analysis for the previously deformed cutslope calculates factors of safety (FS) of 1.07 and 0.98-0.99 for static and pseudo-static loading conditions, respectively. Seismic slope deformation analysis predicts less than 6.6 feet of displacement resulting from slope movements at depths of less than 20 to 60 feet, and displacements of 1 to 3 centimeters for a deep-seated failure surface. ENGEO concurs with MMI's conclusion that future static or seismic slope movements are unlikely to adversely affect Chevron's Tank 1799.

- Rockfall analysis concludes that rock fall hazards could be effectively managed with a 100-foot setback (catchment) area at the toe of the quarry cutslope, with improved performance through installation of a 10-foot-high soil berm at the outer edge of the catchment.

- Three stabilization alternatives were evaluated for the failed quarry cutslope, including 1) buttressing with engineered fill, 2) a combination of buttressing with engineered fill and unloading of the upper cutslope with structurally retained cuts, and 3) structural retention of the cutslope. All three stabilization alternatives were deemed infeasible due to construction-related impacts and/or unjustifiable costs when considering perceived risks to existing or future improvements.

- ENGEO concludes that existing cutslope conditions "*do not pose an undue risk to public safety or existing improvements, including Chevron storage tanks adjacent to the slope*." Further, ENGEO opines "*that the slope can be adequately managed in [a] manner that would be consistent with State guidelines for reclamation slope performance*." Suggested management measures include annual geotechnical monitoring, maintenance of vegetation and drip irrigation systems, establishment of a 100-foot wide setback zone at the toe of the cutslope, and implementation of best management practices to control the release of sediment from the slope.

MMI's September 7, 2007 report titled "*Geoengineering Evaluation of the Static and Seismic Slope Stability of Tank T-1799*" presented the following key findings with relation to existing quarry cutslopes at and adjacent to the subject site:

- Quarry cutslope deformations are relatively shallow and do not pose a risk to Chevron Tank 1799 under either static or seismic loading conditions. "*A combination of toppling, slumping, and wedge type failures can be geologically expected for the complex rock mass and is consistent with observed distress on the quarry slope.*"

- Slope stability analysis for critical cross-section A-A' (as established by ENGEO) on the quarry cutslope calculates a static FS of 1.49, and pseudo-static FS of 1.04 and 1.32 for major earthquake events on the Hayward Fault and San Andreas Fault, respectively.

- The ridge top between the quarry cutslope and the Chevron Tank 1799 cutslope has failed progressively at least 10 feet in a southwestward direction since the 1950's. This failure is evident as the up to 8-foot high main scarp that displaces the quarry cutslope, ridge top, and Tank 1799 cutslope, and several smaller, sub-parallel scarps extending across the quarry cutslope, ridge top, and upper part of the Tank 1799 cutslope. Slope stability analysis for critical cross-section G2-G2' as established by MMI (running along the ridge line between the quarry cutslope and Tank 1799 cutslope in a north-northeastern, south-southwestern direction) calculates a static FS of 1.15, and pseudo-static FS of less than 1.0 for earthquakes on both the Hayward Fault and San Andreas Fault.

- The ridge top failure has resulted in lateral ground bulging of the Tank 1799 cutslope. The base of the ridge top failure is likely between 70 feet and 90 feet below the ridge top but does not extend beneath Tank 1799.

- Expected small volumes of debris generated from shallow failures of the Tank 1799 cutslope during a large earthquake can be managed by installation of a designed remediation option.

DISCUSSION: A summary of geotechnical reports, regulatory considerations, and mitigation alternatives, are further discussed below.

Summary of geotechnical reports: Based on the findings of ENGEO and MMI to date, and on-site observations of the slopes, continued deformation of the quarry cutslope is likely to occur. Both ENGEO and MMI conclude it is unlikely that slope failure would significantly adversely impact Chevron Tank 1799. ENGEO concludes that portions of the quarry cutslope that have previously failed remain unstable. MMI does not support this conclusion and reports that the FS for the deformed quarry cutslope are adequate for static and pseudo-static slope stability. However, MMI concludes that the ridge line that separates the quarry cutslope and Chevron Tank 1799 may be unstable, with calculated static FS of significantly less than 1.5 and calculated seismic loading FS of less than 1.0. MMI anticipates that additional ridge top failure could result in continued displacement of the ridge top in a south-southwest direction. It is unclear whether MMI believes such displacement would result in further deformation of the quarry cutslope.

One area of particular concern relates to the potential for future wedge-type failures occurring on the quarry cutslope. There is some discrepancy between ENGEO and MMI in their discussions of wedge-type failure. Both ENGEO (Page 32) and MMI (Page 52) indicate that variations in joint and bedding data kinematically allow for formation of potentially unstable wedges. However, ENGEO states (Page 32) that "…*no evidence of wedge failures has been observed on the slope*", whereas MMI states (Page 28) "*Many wedge failures were observed, at least one of which was at bench-scale. The failure was bounded by steep failure surfaces trending northwest and northeast*."

Visual observation of pre-SMARA slopes directly southwest of the quarry cutslope reveal steep, intersecting, planar rock surfaces that strike to the northwest and northeast and dip moderately to steeply to the southwest and northwest, respectively. Bedding and inferred joint orientations shown on ENGEO's Geologic Map (Figure 5A) support such observations.

Regulatory considerations: The discussion now shifts to possible alternatives for reclamation of the quarry cutslope. SMGB regulations contain specific requirements for proposed final (reclaimed) cutslopes. Specifically, CCR Section 3704(f) states:

> "*Cutslopes, including final highwalls and quarry faces, shall have a minimum slope stability factor of safety that is suitable for the proposed end use and conform with the surrounding topography and/or approved end use.*"

CCR Section 3502(b)(3) states, in part:

> "*The designed steepness and proposed treatment of the mined lands' final slopes shall take into consideration the physical properties of the slope material, its probable maximum water content, landscaping requirements, and other factors. In all cases, reclamation plans shall specify slope angles flatter than the critical gradient for the type of material involved.*"

CCR Section 3501 defines Critical Gradient as:

> "*The maximum stable inclination of an unsupported slope under the most adverse conditions that it will likely experience, as determined by current engineering technology.*"

CCR Section 3700(b) states:

> "*Where an applicant demonstrates to the satisfaction of the lead agency that an exception to the standards specified in this article is necessary based upon the approved end use, the lead agency may approve a different standard for inclusion in the approved reclamation plan. Where the lead agency allows such an exception, the approved reclamation plan shall specify verifiable, site-specific standards for reclamation. The lead agency may set standards which are more stringent than the standards set forth in this Article; however, in no case may the lead agency approve a reclamation plan which sets any standard which is less stringent than the comparable standard specified in this Article.*"

Mitigation Alternatives: ENGEO provided a summary of mitigation alternatives in their recent report titled: "*Discussion of Conceptual Slope Mitigation Options*," dated April 24, 2008. ENGEO describes conceptual mitigation measures to address the stability of the failed cutslope with respect to an industrial end use. The initial presentation of the alternatives and geotechnical analyses to back up the conceptual design are presented in ENGEO's October 18, 2007 report; however, treatment of each alternative is not consistent, and necessary information that would allow for a complete and independent assessment of the feasibility and reasonableness of each alternative was not included in either of their reports. For example, stability analyses should be presented for each mitigation alternative considered, and for mitigation alternatives considered yet excluded from the discussion (i.e., a buttress with a 2:1 slope).

The purposes of ENGEO's April 24, 2008 report are to provide more information on the conceptual slope mitigation options presented in their October 18, 2007 report, and to provide preliminary estimates of construction quantities, costs, and impacts for each alternative, which collectively are meant to represent a range of typical mitigation measures

for stabilization of rock slopes. The discussion of each alternative relies on an approach of comparing "conceptual advantages," "conceptual impacts," and estimated costs to make conclusions about the feasibility of a particular measure. Table 5 of their report summarizes the results of this exercise with the following options discussed:

Alternative 1 – Imported Fill Buttress

Alternative 2 – Ridge Cut\Fill Buttress Balanced on Site

Alternative 3 – Cut\Fill Buttress Balanced on Site with Retained Slope

Alternative 4 – Structural Slope Stabilization; and

Alternative 5 – Slope Setback, Monitoring, and Maintenance.

Alternative 5 is the least costly by an order of magnitude, and ENGEO and Dutra reportedly favor this alternative, presumably because it will have the least impact on the environment and infrastructure of the mine site and surrounding area. In fact, ENGEO's report indicates that Alternative 5 will have no impacts. However, the report does not carefully and adequately consider all advantages and impacts of each mitigation alternative.

For example, the report suggests that one of the impacts that makes Alternatives 1, 2, and 3 not feasible is that work would be required outside of the mining lease boundary. The analysis of these alternatives neglects to recognize or acknowledge the significance of the mining-triggered landslide extending outside of the reclamation boundary. The encroachment of the landslides on the adjacent property is inconsistent with the approved reclamation plan, and the amended reclamation must incorporate all areas affected by the surface mining operation, including all areas affected by the landslide. Therefore, describing work outside the mining lease boundary as an impact is correct, but it is erroneous to use the impact as support for stating that a mitigation alternative is not feasible. Furthermore, the discussion of the preferred mitigation alternative, Alternative 5, fails to mention that the presence of the active landslide triggered by mining outside of the mining boundary is a very important impact. The report does not recognize the following impacts for Alternative 5, among others:

- An unstable mined cutslope would remain following reclamation;
- Future landslide movement more than 10 years from now is not addressed;
- An exclusionary setback at the base of the slope should be deeded in the property, possibly reducing the property value;

- An exclusionary setback should also be established along the upper part of the slope and deeded in the property, further reducing the property value;

- The landslide and all of the setbacks should be included in the boundaries of the amended reclamation plan; and

- The presence of an unstable cutslope is inconsistent with the SMGB's regulations that state, "*Cutslopes, including final highwalls and quarry faces, shall have a minimum slope stability factor of safety that is suitable for the proposed end use and conform with the surrounding topography and/or end use*" (CCR section 3704(f)).

The assessment of the preferred alternative as presented by ENGEO is a preliminary assessment of possible alternatives for consideration but is inadequate for conduct of a comprehensive analysis of mitigation alternatives. Essentially, the approach proposed is to conduct minimal monitoring and leave an unstable slope that will continue to fail and degrade into a potential eyesore and hazard to the public and the environment. The approach also only focuses on the next movement and does not consider the long-term effects on the slope and the safety of the tanks. The assessed feasibility of each alternative does not recognize the importance of the requirements of SMARA, which states that final mined slopes should be stable and properly revegetated.

Stable slopes and successful revegetation are conceptual advantages for Alternatives 1 through 4, but these advantages are downplayed in the study by narrowly interpreting that the end use will be industrial for the entire site. The industrial end use and appropriate SMGB-defined factor of safety are used to inflate the stated impacts and estimated costs for Alternatives 1 through 4 rather than providing other, possibly more practical solutions to the problem.

Conclusions: The Executive Officer offers the following conclusions for the Committee's consideration:

- End use acceptability: The current end use for the quarry floor is development of additional petroleum storage tank area (industrial). This end use is not considered acceptable in light of ENGEO's and MMI's findings pertaining to the failed cutslope and ridge line, and when considering SMGB Regulations (CCR Sections 3501, 3502(b)(3), and 3704(f)). An industrial end use for the quarry floor would be acceptable if the quarry cutslopes could be definitively demonstrated to be stable, which has not been accomplished to date.

- Appropriateness of Proposed Mitigation Alternative 5: As proposed in ENGEO's April 24, 2008 report discussing proposed alternatives, Alternative 5 should be

rejected, because it does not acknowledge and address important impacts of the existing unstable slope, especially the fact that increasing the gross stability of the cutslope would not occur. It is therefore recommended that a more detailed and exhaustive analysis of possible mitigation alternatives be conducted prior to further consideration by the SMGB of a strictly monitoring and maintenance option for the quarry cutslope. An alternative end use, such as open-space, may be acceptable for the quarry floor and cutslope. However, there are no situations in which an unstable slope has been accepted as final under an approved reclamation plan.

- Feasibility of Mitigation Alternatives 1 through 4: Alternatives 1 through 4 and other possible alternatives should be considered feasible; however, insufficient details about each alternative were presented in the available reports to draw firm conclusions. For example, the results of the stability analysis for a fill buttress that slopes 2:1 (horizontal to vertical) was not presented, but it was stated that the factors of safety would be lower than that required for an end use of industrial development. It is unclear if a 2:1 sloping buttress would have a suitable factor of safety for an open space end use. For example, the stabilized slope and the 100-foot setbacks above and below the slope could have an open space end use, and the remaining floor of the mine could keep the current industrial end use. In this scenario the costs and potential impacts of construction would be lowered, and the overall stability of the cutslope would be increased. Similar approaches with the other alternatives, or other mitigation alternatives not yet explored, may be more cost effective and result in increased stability of the mined cutslope.

- Potential for Adverse Impact on Above-Ground Storage Tanks: ENGEO's and MMI's conclusion that relative risks posed to the existing Chevron Tank 1799 due to future slope failure are low is reasonable. MMI concludes "*There is no evidence that the primary ridge top scarp ("upper scarp") extended beneath the Tank*." However, this conclusion is very different than a much stronger conclusion of providing evidence that the upper scarp or any other shear plane associated with the unstable cutslope does not extend beneath the tank. Continued failure of portions of the quarry cutslope and/or ridge top area is expected, and therefore the final quarry cutslope is considered to be subject to further, and potentially significant, deformation. Such continued deformation, and its overall impact on existing above-ground tanks, is of continued concern.

By way of comparison, SMGB staff note that the Pt. Richmond (Canal) Quarry, located approximately 2.5 miles southwest of the subject quarry and situated in a nearly identical geologic setting, recently dealt with mitigation of complex slope failures, albeit at a relatively smaller scale (total slope repair height of approximately 200 feet versus approximately 250

feet for the subject site). The solution in the Point Richmond (Canal) Quarry case, which was incorporated into the reclamation plan approved by the SMGB on November 8, 2007, involved a combination of engineered fill slope buttress construction, and rock bolt installation. Acceptable static and pseudo-static factors of safety were calculated based on the approved slope mitigation for a range of possible end uses at this site, including industrial, office building, and tank farm. The approved financial assurance mechanism for the Point Richmond (Canal) Quarry site reclamation, which includes the approved slope repair and other reclamation activities, stands at approximately $3.1 million.

EXECUTIVE OFFICER'S RECOMMENDATIONS: The Executive Officer offers the following recommendations for the Committee's consideration:

- End use acceptability: It is recommended that the eventual end use of the site be clarified and re-evaluated, as appropriate.

- Appropriateness of Proposed Mitigation Alternative 5: It is recommended that a more detailed and exhaustive analysis of possible mitigation alternatives be conducted prior to further consideration by the SMGB of a strictly monitoring and maintenance option for the quarry cutslope.

- Feasibility of Mitigation Alternatives 1 through 4: It is recommended that Alternatives 1 through 4, and other possible albeit practical alternatives, be further considered.

- Potential for Adverse Impact on Above-Ground Storage Tanks: A risk assessment and a strategy to monitor potential ground movement in close vicinity to Tank 1799 should be explored.

Respectfully submitted:

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Stephen M. Testa
Executive Officer